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(54) PROJECTION ALIGNER

(57)Abstract:
PURPOSE: To observe or project a specific mark satisfactorily even if a pupil filter is inserted in order to observe or project the mark through the intermediary of a projection optical system.
CONSTITUTION: An alignment mark 8B on a reticle is irradiated with lighting beams IL2 led through the intermediary of an optical fiber 23 so as to irradiate a reference mark 22 on a wafer stage 13 side through the intermediary of a projection optical system 3. If the reference mark 22 is formed of an assembly of fine patterns such as contact hole patterns, the diffraction beams from the reference mark 22 reach the image pickup elements 29X, 29Y passing around a pupil filter 4 in the projection optical system 3. Finally, the image of the reference mark 22 and the image of the alignment mark 8B are to be overlapped with each other for the image formation.

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CLAIMS

[Claim(s)]

[Claim 1] In the projection aligner which projects the pattern on a mask through a projection optical system on the sensitization substrate held on the substrate stage freely movable in a flat surface vertical to the optical axis of this projection optical system The pupil filter arranged near the pupil surface of said projection optical system, or this pupil surface, The projection aligner characterized by having the reference mark formed on said substrate stage by whenever [which embraced the configuration of said pupil filter / detailed], a lighting means to illuminate said reference mark by the illumination light, and a light-receiving means to receive the illumination light which passed through said projection optical system after generating from this reference mark.

[Claim 2] In the projection aligner which projects the pattern on a mask through a projection optical system on the sensitization substrate held on the substrate stage freely movable in a flat surface vertical to the optical axis of this projection optical system The pupil filter arranged near the pupil surface of said projection optical system, or this pupil surface, The projection aligner characterized by having a lighting means to illuminate the reference mark formed on said mask by whenever [which embraced the configuration of said pupil filter / detailed] by the illumination light, and a light-receiving means to receive the illumination light which passed through said projection optical system after generating from this reference mark.

[Claim 3] The projection aligner according to claim 1 or 2 characterized by making it distribution of the integral value to the non-measuring direction vertical to said predetermined measurement direction of the bright section of said reference mark become homogeneity when said reference mark is considered as the mark which shows the location of the predetermined measurement direction.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Industrial Application] This invention is applied to the projection aligner equipped with the function to perform measurement of reticle alignment, superposition precision, or the image formation property of a projection optical system etc. especially through a projection optical system, about the projection aligner used in case a semiconductor device or a liquid crystal display component is manufactured at a photolithography process, and is suitable.

[0002]

[Description of the Prior Art] The projection aligner exposed on the wafers (or glass plate etc.) with which the image of a photo mask or the pattern of reticle ("reticle" is hereafter used as an example) was applied to the photoresist through the projection optical system at the photolithography process for manufacturing a semiconductor device or a liquid crystal display component is used. In this projection aligner, in order to perform alignment (reticle alignment) of the reticle to the wafer stage in which the wafer was laid in advance of exposure to accuracy, the alignment system which observes simultaneously the alignment mark formed on reticle and the reference mark formed on the wafer stage through a projection optical system is used.

[0003] Reference mark FM1 which consists of four straight-line patterns shown in drawing 12 (a) is an example of the reference mark on the wafer stage used when performing reticle alignment, and the alignment mark RM 1 of the cross-joint mold shown in drawing 12 (b) is an example of the mark on the reticle corresponding to it. Reference mark FM1 is used as criteria of the location of the direction of X which intersects perpendicularly mutually, and the direction of Y. Within the observation visual field on reticle, if a reference mark is observed through a projection optical system in this case with a two-dimensional image sensor from on reticle, as shown in drawing 13 (a), the alignment mark RM 1 and reference mark image FM1P will lap, and will be observed. If an image pick-up signal is read along with the scanning line on the image sensor corresponding to the scanning line SL parallel to the X-axis on that drawing 13 (a), the signal shown in drawing 13 (b) will be acquired, and the amount of location gaps of the direction of X of the alignment mark RM 1 to reference mark image

FM1P will be calculated from this signal there. Similarly, the amount of location gaps to the direction of Y is also calculated. Thus, reticle alignment is performed by driving the amount of location gaps of the called-for alignment mark RM 1 into a predetermined value.

[0004] Moreover, in the projection aligner, since it was necessary to store the inclination (reticle rotation) of the reticle not only to the two-dimensional location of reticle but the system of coordinates on a wafer stage in predetermined tolerance, measurement of reticle rotation was performed by the so-called stage luminescence type of ISS (Imaging Slit Senser) system as follows. In this case, the ISS mark FM 2 which consists of a slit-like opening pattern along the direction of Y as shown in drawing 14 (a) is formed in a wafer stage side, and on reticle, as shown in drawing 14 (b) corresponding to it, the straight-line pattern-like alignment mark RM 2 is formed.

[0005] If a wafer stage is scanned in the direction of X at this time where the ISS mark FM 2 is illuminated from a base side, as are shown in drawing 15 (a), and the alignment mark RM 2 crossed in bright ISS mark image FM2P in the direction of X, it will move on reticle. Then, if photo electric translation of the flux of light which penetrated reticle is received and carried out, as shown in drawing 15 (b), the signal which changes according to the location of the direction of X of a wafer stage will be acquired, and the location of the alignment mark RM 2 will be measured from a location in case the signal becomes min. Furthermore, the tilt angle of reticle [as opposed to / when it asks for the location of the direction of X of the 2nd alignment mark / the Y-axis on / the difference of the location of two alignment marks to / a wafer stage] left and formed in the direction of Y, for example on reticle is measured.

[0006] If the ISS mark FM 4 which consists of an opening pattern of a cross-joint mold as a reference mark is used by using the ISS mark FM 3 which similarly consists of a slit-like opening pattern along with the X-axis as shown in drawing 16 (a) as a reference mark by the side of a wafer stage as the reticle rotation to the X-axis on a wafer stage is measured and it is shown in drawing 16 (b), the reticle rotation to the X-axis and a Y-axis will be measured.

[0007] since [moreover,] it may generally be carried out at a photolithography process using the projection aligner with which the exposure to the layer from which it differs on a wafer differs -- ******** -- in order to store the superposition error between layers in tolerance, it is necessary to store the distortion of the projection optical system with which each projection aligner was equipped in predetermined tolerance, respectively Therefore, the distortion of a projection optical system was measured by exposing the pattern of for example, test reticle on a wafer through a projection optical system

conventionally at a duplex actually, and measuring the location gap by each point of the obtained image by the so-called laser step alignment method (henceforth a "LSA method").

[0008] As the test reticle, as shown in drawing 18 , the reticle by which the mark RM 3 for assessment which arranges the dot pattern of the square of width of face d of one side (d is 20 micrometers) to a single tier, respectively, and becomes was arranged in all directions in the predetermined pitch was used. And by 1st exposure, the pattern of the whole surface of the test reticle was exposed as a main scale, and by the 2nd exposure, the image of the predetermined mark for assessment on test reticle was exposed as a vernier by each point on a wafer, respectively, carrying out stepping actuation of the wafer stage. Then, by the LSA method, the amount of location gaps of two marks on each point was detected by scanning two marks exposed by each point on a wafer at an optical slit-like spot, and detecting the diffracted light from each mark. Furthermore, the superposition precision of two patterns exposed with such a double exposure method by the layer from which it differs on a wafer was also measured.

[0009]

[Problem(s) to be Solved by the Invention] As mentioned above, in the conventional projection aligner, location detection or projection of versatility of a mark was performed through the projection optical system. The attempt which raises the image formation engine performance of the projection optical system at the time of exposing a predetermined pattern is made by installing the optical filter (henceforth a "pupil filter") which has a predetermined permeability distribution property and a predetermined phase distribution property near the pupil surface (Fourier transform side) of a projection optical system about this recently. For example, in order to improve the resolution at the time of exposing an isolated pattern like a contact hole pattern, and the depth of focus, it turns out that it is good to install the pupil filter of the protection-from-light mold which shades the circular field near an optical axis near the pupil surface of a projection optical system as indicated by JP,4-179958,A as an example.

[0010] Drawing 17 (a) is the principle explanatory view of an operation of the pupil filter of a protection-from-light mold, and the image of the detailed contact hole pattern 2 on reticle 1 is exposed on a wafer 5 through a projection optical system 3 in this drawing 17 (a). In this case, the pupil filter 4 which shades the circular field of a radius r centering on an optical axis on the pupil surface FP of a projection optical system 3 is arranged. A radius r is 0.8a when the radius of the pupil of a projection optical system 3 is set to a. In this case, if the exposure light IL is irradiated by reticle 1, the intensity

distribution in the pupil surface FP of the projection optical system 3 of the diffracted light injected from the contact hole pattern 2 will turn into distribution which has a comparatively big value also in the field of the exterior of a pupil as a distribution curve 6 shows. Therefore, if image formation of the image of the contact hole pattern 2 is carried out using the light which only passes the whole pupil, the resolution of the image obtained will worsen.

[0011] If the pupil filter 4 is installed in the pupil surface FP to it as shown in drawing 17 (a), according to the apodization effectiveness, drawing which expanded the intensity distribution of the image obtained on a wafer 5 in the direction of X will become like the curve 7 of 17 (b), and spacing from the peak of an image to the first zero point will become short. Namely, resolution improves and the enhancement effect of the depth of focus is also obtained by coincidence at this time.

[0012] Thus, if the pupil filter 4 of a protection-from-light mold is installed on the pupil surface FP of a projection optical system 3, the image formation property of a projection optical system 3 over a contact hole pattern can be raised. However, when reference mark FM1 shown in drawing 12 (a) through the projection optical system 3 in which the pupil filter 4 was inserted in this way should be detected and reticle alignment should be performed, many of light from reference mark FM1 was interrupted by the pupil filter 4, the quantity of light fell, and there was inconvenience that reticle alignment could not be carried out to high degree of accuracy as a result. Even if similarly it was going to lead the light from the ISS mark FM 2 shown in drawing 14 (a) to the reticle side through the projection optical system 3 inserted in the pupil filter 4, many of light from the ISS mark FM 2 will be interrupted by the pupil filter 4, and there was inconvenience that high degree of accuracy could not be asked for reticle rotation.

[0013] Moreover, even if it was going to expose the image of the alignment mark RM 3 of the shape of a dot pattern train as shown in drawing 18 </A> on the wafer through the projection optical system 3 inserted in the pupil filter 4, many of light from the alignment mark RM 3 will be interrupted by the pupil filter 4, and there was inconvenience that an image measurable easily [the alignment mark] on a wafer did not carry out image formation . Therefore, there was inconvenience that measurement of the distortion property of a projection optical system 3 that the pupil filter 4 was inserted was difficult, and measurement of the superposition error of the projection aligner equipped with the projection optical system 3 was also difficult.

[0014] This invention aims at offering the projection aligner which can perform observation or projection of the mark good, when performing observation or projection of predetermined of a mark in view of this point through the projection optical system in

which the pupil filter was inserted.

[0015]

[Means for Solving the Problem] The 1st projection aligner by this invention minds a projection optical system (4) for the pattern on a mask (1), as shown in drawing 1 . In the projection aligner projected on the sensitization substrate (5) held on the substrate stage (13) freely movable in a flat surface vertical to the optical axis of this projection optical system The pupil filter arranged the pupil surface of a projection optical system (3), or near this pupil surface (optical compensation plate) (4), The reference mark formed on the substrate stage (13) by whenever [which embraced the configuration of the pupil filter / detailed] (22), It has a lighting means (23-25, 26A, 27, 3) to illuminate the reference mark by the illumination light, and a light-receiving means (27, 26A, 26B, 29X, 29Y) to receive the illumination light which passed through the projection optical system (3) after generating from a reference mark (22).

[0016] Next, as the 2nd projection aligner by this invention is shown in drawing 9 In the projection aligner which projects the pattern on a mask (46) through a projection optical system (3) on the sensitization substrate (5) held on the substrate stage (13) freely movable in a flat surface vertical to the optical axis of this projection optical system The pupil filter arranged the pupil surface of that projection optical system, or near this pupil surface (4), It has a lighting means (10-12) to illuminate the reference mark (Mij) formed on the mask by whenever [which embraced the configuration of a pupil filter (4) / detailed] by the illumination light, and a light-receiving means (48 49) to receive the illumination light which passed through the projection optical system (4) after generating from the reference mark.

[0017] When these reference marks (22 Mij) are considered as the mark which shows the location of the predetermined measurement direction in these cases, it is desirable to equalize distribution of the integral value to the non-measuring direction vertical to the predetermined measurement direction of the bright section (in a reflective mold, it is the light transmission section with the reflective section and a transparency mold) of these reference marks.

[0018]

[Function] According to the 1st projection aligner of this this invention, when a pupil filter (4) is a pupil filter of the main protection-from-light mold which shades the light near an optical axis, the reference mark (22) on a substrate stage (13) is formed from the aggregate of a detailed dot pattern, for example, as shown in drawing 2 (a). Thereby, many of diffracted lights generated from a reference mark (22) come to pass through the field which is distant from an optical axis by the pupil surface of a projection optical

system (3), and it can receive the light from a reference mark (22) with sufficient quantity of light with a light-receiving means. Therefore, even if the pupil filter (4) is arranged, a reference mark (22) is detectable to accuracy.

[0019] Thus, if the measurement direction of a reference mark (22) is made into the direction of X as shown in drawing 2 (a) when a reference mark (22) is constituted from a dot pattern, distribution will be set up so that the integral value to the non-measuring direction of the bright section of the mark (22X) for the X-axes of a reference mark (22) may equalize, as the distribution curve (43) of drawing 3 shows. And in case the location of a mark (22X) is detected, the image of a mark (22X) is repeatedly scanned many times for example, in the direction of X, and this scan result is equalized. Thereby, the location of the direction of X of a mark (22X) is detectable to high degree of accuracy with high repeatability.

[0020] Next, according to the 2nd projection aligner of this invention, when a pupil filter (4) is a pupil filter of the main protection-from-light mold which shades the light near an optical axis, the reference mark (Mij) on a mask (46) is formed from the aggregate of a detailed dot pattern, for example, as shown in drawing 10 (a). Thereby, many of diffracted lights generated from a reference mark (Mij) come to pass through the field which is distant from an optical axis by the pupil surface of a projection optical system (3), and it can receive the light from a reference mark with sufficient quantity of light with a light-receiving means. Therefore, even if the pupil filter (4) is arranged, a reference mark (Mij) is detectable to accuracy.

[0021] Thus, if the measurement direction of a reference mark (Mij) is made into the direction of X as shown in drawing 10 also when a reference mark (Mij) is constituted from a dot pattern, the location of the direction of X of the mark is detectable to high degree of accuracy with high repeatability by setting up distribution so that the integral value to the non-measuring direction of the bright section of the mark for the X-axes of the reference mark may equalize.

[0022]

[Example] Hereafter, with reference to drawing 1 - drawing 3 , it explains per 1st example of the projection aligner by this invention. This example applies this invention, when performing reticle alignment through a projection optical system. Drawing 1 shows the projection aligner of this example, in this drawing 1 , reticle 1 is the original edition for contact hole patterns, the subject-copy pattern of a contact hole pattern is formed in the pattern space of reticle 1 in a predetermined array, and two alignment marks 8A and 8B are formed near the direction of X of that pattern space. Alignment mark 8B (the same is said of the 8A) is the mark of the cross-joint mold which consists

of reflective film (light-shielding film), as shown in drawing 2 (b), and the perimeter serves as the transparency section.

[0023] In case the pattern of reticle 1 is exposed, the exposure light IL 1 from the light source for non-illustrated exposure (i line or excimer laser light of a mercury lamp etc.) carries out incidence to the fly eye lens 10, and the exposure light from the secondary light source of a large number formed in the injection side of the fly eye lens 10 illuminates the pattern space of reticle 1 through a mirror 11 and a condenser lens 12. Under the exposure light, the image through the projection optical system 3 of the pattern in the pattern space of reticle 1 is exposed by each shot field of the wafer 5 held on the wafer stage 13.

[0024] The pupil filter (optical compensation plate) 4 of the protection-from-light mold which shades the light of the circular field of a predetermined radius centering on the optical axis AX of a projection optical system 3 on the Fourier transform side (pupil surface) FP over the pattern formation side of the reticle 1 of the projection optical system 3 is arranged. Thereby, the image of a contact hole pattern is high resolution, and projection exposure is carried out on a wafer 5 with the deep depth of focus.

[0025] Here, if the Z-axis is taken to the optical axis AX of a projection optical system 3 at parallel and the X-axis and a Y-axis are set as the rectangular coordinate system of a two-dimensional flat surface vertical to the Z-axis, the wafer stage 13 consists of an X-Y stage which positions a wafer 5 in XY flat surface vertical to the Z-axis, a Z stage which adjusts the location of the wafer 5 of Z shaft orientations. Moreover, the migration mirror 14 is fixed to the edge of the wafer stage 13, by the laser interferometer 15 installed in this migration mirror 14 and exterior, the X coordinate and Y coordinate of the wafer stage 13 are always measured, and the measured coordinate is supplied to the main control system 16 and operation part 17. The main control system 16 controls the migration coordinate of the wafer stage 13 through the wafer stage actuator 18 based on the measured coordinate.

[0026] Moreover, the incident light study system 19 which projects a slit pattern image on the side of a projection optical system 3 aslant to an optical axis AX at the predetermined measure point in the exposure field of a projection optical system 3, The reflected light from that measure point is received, re-image formation of that slit pattern image is carried out, and the autofocus sensor which consists of a light-receiving system 20 which generates the focal signal according to the amount of gaps from the criteria location of this location by which re-image formation was carried out, and is supplied to the main control system 16 is formed. In this case, in the condition that that measure point has agreed in the image formation side (best focus side) of a projection

optical system 3, the calibration is performed so that that focal signal may be set to 0, and the amount of location gaps from the best focus side of the exposure side of a wafer 5 can be detected from the value of that focal signal.

[0027] Furthermore, the reference mark plate 21 which consists of a glass substrate near the wafer 5 on the wafer stage 13 is fixed, and the reference mark 22 is formed in the front face of this reference mark plate 21. At the time of reticle alignment, the front face of the reference mark plate 21 is set as the same height as the image formation side of a projection optical system 3 using an autofocus sensor. Drawing 2 (a) is the enlarged drawing of that reference mark 22, and as shown in this drawing 2 (a), the reference mark 22 is formed from two Y shaft-bases mark 22Y left and formed in two X shaft-basis mark 22X left and formed in the direction of X, and the direction of Y. Moreover, the thing and Y shaft-basis mark 22Y which distributed over two rectangle fields long in the direction of Y the minute dot pattern 42 which X shaft-basis mark 22X becomes from the reflective film, respectively distribute over two rectangle fields long in the direction of X the minute dot pattern 42 which consists of reflective film, respectively, and fields other than dot pattern 42 are nonreflective nature. In other words, the reference mark 22 of this example distributes a dot pattern 42 over the rectangle field of conventional reference mark FM1 shown in drawing 12 (a) in a predetermined array, respectively.

[0028] The magnitude of the dot pattern 42 may be magnitude comparable as the projection image to the wafer 5 top of the contact hole pattern in the pattern space of reticle 1, and any, such as circular or a rectangle, are sufficient as a configuration. When a dot pattern 42 is circular, an example of the path is about 0.3 micrometers, and the array pitch to the direction of X and the direction of Y is about 0.75 micrometers.

[0029] As distribution of the dot pattern, as shown in drawing 2 (a), distribution from which the distribution which integrates with a dot pattern 42 in the direction (the non-measuring direction) of Y, and is acquired becomes homogeneity is chosen, and distribution from which the distribution which integrates with a dot pattern 42 in the direction of X (the non-measuring direction), and is acquired becomes homogeneity is chosen by Y shaft-basis mark 22Y at X shaft-basis mark 22X. That is, in X shaft-basis mark 22X, a dot pattern 42 is arranged along with the straight line of a large number parallel to the X-axis which is the measurement direction, and its location of the dot pattern 42 on each straight line is mutually random. Moreover, in Y shaft-basis mark 22Y, a dot pattern is arranged along with the straight line of a large number parallel to the Y-axis which is the measurement direction, and the location of the dot pattern on each straight line is mutually random.

[0030] Next, in this example, the alignment microscope for observing the physical relationship of alignment mark 8B and a reference mark 22 from the upper part of reticle 1 is formed. In case reticle alignment is performed using this alignment microscope, the illumination light IL 2 of the same wavelength as the exposure light IL 1 is drawn from the light source for exposure (un-illustrating) through an optical fiber 23. The illumination light IL 2 injected from the optical fiber 23 illuminates near the alignment mark 8B of reticle 1 through the mirror 27 for objective lens 26A and optical-path bending, after the parallel flux of light is mostly formed by the collimator lens 24 and being reflected by the beam splitter 25.
[0031] In this case, the illumination light IL 2 which penetrated the perimeter of alignment mark 8B illuminates the reference mark 22 top on the reference mark plate 21 through a projection optical system 3 as that by which the reference mark 22 by the side of the wafer stage 13 is set as alignment mark 8B and a location [**** / almost]. In this example, since the pupil filter 4 is installed on the pupil surface FP of a projection optical system 3, the numerical aperture (flare angle) of the illumination light IL 2 which illuminates alignment mark 8B needs to be the large value which reaches to the field around the pupil filter (protection-from-light section) 4.
[0032] The reflected light from the reference mark 22, the scattered light, and the diffracted light pass through the perimeter of the pupil filter (protection-from-light section) 4 of a projection optical system 3, and return to reticle 1. In this case, since a reference mark 22 is the aggregate of a minute dot pattern, its angle of diffraction of the diffracted light is large. Therefore, since many of diffracted lights from a reference mark 22 pass through the perimeter of the pupil filter 4 and it returns to reticle 1, there is an advantage which can observe the image of a reference mark 22 with an SN ratio high as a bright image. The light from the reference mark 22 which passed reticle 1, and the light diffracted [were diffracted and it was scattered / were diffracted and it was straight-line-reflected / were scattered about and / about] by alignment mark 8B of reticle 1 return to objective lens 26A through both the mirrors 27. The light returned to objective lens 26A carries out image formation of the image of alignment mark 8B, and the image of a reference mark 22 to image sensor 29X for the X-axes which consists of two-dimensional CCD, respectively, and the image pick-up side of image sensor 29Y for Y-axes in piles through a beam splitter 25, image formation lens 26B, and a beam splitter 28.
[0033] Drawing 3 shows the observation visual field near [under the alignment microscope of drawing 1] alignment mark 8B, in this drawing 3 , image formation of the image 22XP of X shaft-basis mark in a reference mark 22 is carried out so that long

X-axis mark 8BX may be inserted in the direction of Y of alignment mark 8B, and image formation of the image 22YP of Y shaft-basis mark is carried out so that long Y-axis mark 8BY may be inserted in the direction of X. And the image of field 30X of a long rectangle is picturized by image sensor 29X of drawing 1 in the direction of X, and the image of field 30Y of a long rectangle is picturized by image sensor 29Y in the direction of Y. Furthermore, in image sensor 29X, an image pick-up signal is read from a two-dimensional pixel along with 311-31 Ns (N is two or more integers) of scanning lines parallel to the X-axis, and the scanning line [****], and it is 321-32 Ns of scanning lines parallel to a Y-axis in image sensor 29Y. Along with the scanning line [****], an image pick-up signal is read from a two-dimensional pixel. Thus, the image pick-up signal by which reading appearance was carried out is supplied to the operation part 17 of drawing 1 , and computes the amount of location gaps from the supplied image pick-up signal to the direction of X and the direction of Y over an image of a reference mark 22 of alignment mark 8B in operation part 17.
[0034] In this case, at operation part 17, it is 311-31 Ns of scanning lines of drawing 3 , for example. Based on the signal which equalized the image pick-up signal on the corresponding scanning line, and was acquired, the amount of location gaps of X-axis mark 8BX to image 22XP of X shaft-basis mark is computed. However, the signal of the field which serves as a high level in all the range mostly among these scanning lines, i.e., the field in image 8BY of Y shaft-basis mark, is removed. At this time, by this example, as the distribution integrated with and acquired in the direction (the non-measuring direction) of Y shows the bright section of image 22XP of X shaft-basis mark by the distribution curve 43, it becomes distribution with the sharp edge of the ends of the direction of X, and the uniform level of pars intermedia. Therefore, the repeatability of the measurement result of the location of image 22XP of X shaft-basis mark is good, and the amount of location gaps to the direction of X of alignment mark 8B to the image of a reference mark 22 is measured with high degree of accuracy and high repeatability. Similarly, it is measured with repeatability also with the high amount of location gaps to the direction of Y of alignment mark 8B.
[0035] Operation part 17 supplies the value which added the current coordinate value of the wafer stage 13 as offset, and obtained it in the amount of location gaps computed such to the main control system 16. Thereby, the amount of location gaps of alignment mark 8B to the reference mark 22 in case the wafer stage 13 is set as the predetermined criteria location is measured. Similarly, the amount of location gaps to the reference mark 22 (or another reference mark) of alignment mark 8A on the reticle 1 of drawing 1 is measured under the alignment microscope (un-illustrating) arranged on alignment

mark 8A. Reticle alignment is completed by positioning reticle 1 so that the amount of location gaps of these alignment marks 8A and 8B may be stored in predetermined tolerance.

[0036] Since the aggregate of a dot pattern minute as a reference mark 22 on the wafer stage 13 is used as mentioned above according to this example, the angle of diffraction of the diffracted light from a reference mark 22 is large. Therefore, even if the pupil filter 4 of a protection-from-light mold is installed in the pupil surface of a projection optical system 3, a reference mark 22 is observable to accuracy through a projection optical system 3 under the upper alignment microscope of reticle 1. For this reason, reticle alignment can be performed to high degree of accuracy.

[0037] In addition, in the above-mentioned example, although operation part 17 is equalizing the image pick-up signal for example, corresponding to field 30X, two-dimensional low-pass filtering processing may be performed to the image data corresponding to field 30X by the image processing, and you may ask for the average image of image 22XP of X shaft-basis mark. In this case, the location of an alignment mark is detected on the basis of the location of this average image.

[0038] In addition, although the aggregate of a dot pattern is used as a reference mark 22 in the above-mentioned example, as shown in drawing 4 as a reference mark 22, small line - and small - tooth-space pattern of an array pitch may be used. Drawing 4 shows the observation visual field on the reticle observed under an alignment microscope in this case, and image 33YP of line - and - tooth-space pattern with which image 33XP of X shaft-basis mark was arranged in the small pitch in the direction of Y in this drawing 4 , and Y shaft-basis mark is line - and - tooth-space pattern which were arranged in the pitch small in the direction of X. Therefore, the reference mark formed on the wafer stage 13 of drawing 1 is a mark of the magnitude which multiplies those image 33XP and 33YP(s) by the projection scale factor beta of a projection optical system 3, and is obtained.

[0039] Since many of diffracted lights from the reference mark pass through the field of the outside of the pupil filter 4 of a projection optical system 3 and it returns to reticle 1 even when a reference mark like drawing 4 is used, the location of the reference mark is detectable to accuracy. Moreover, the location of a reference mark is detectable with highly precise and high repeatability by, making the scanning line in field 30X correspond for example, and equalizing the image pick-up signal which scans an image pick-up side top and is acquired also in the case of drawing 4 .

[0040] Next, with reference to drawing 5 - drawing 8 , it explains per 2nd example of this invention. This example applies this invention, when measuring reticle rotation, it

gives the same sign to the part corresponding to drawing 1 in drawing 5 , and omits the detail explanation. Drawing 5 shows the projection aligner of this example, and the alignment marks 35A and 35B of the shape of a straight line long in the direction of Y are formed in the outside of the pattern space (field in which the subject-copy pattern of a contact hole pattern was formed) of the reticle 34 held on the reticle holder 9 in this drawing 5 . Moreover, ISS mark 37X for the X-axes is formed into the light-shielding films on the reference mark plate 36 which consists of a glass substrate installed near the wafer 5 on the wafer stage 13 (chromium film etc.).

[0041] Drawing 6 (a) expands and shows that ISS mark 37X, and ISS mark 37X distributes the dot pattern 44 of the light transmission nature which becomes a long rectangle field from minute opening in the direction of Y in a predetermined array in this drawing 6 (a). In other words, ISS mark 37X of this example distributes a dot pattern 44 in opening of the conventional ISS mark FM 2 of drawing 14 (a), and that of the magnitude of a dot pattern 44 is comparable as the contact hole pattern exposed through the projection optical system 3 with pupil filter 4 on a wafer 5.

[0042] Moreover, the measurement direction of the ISS mark 37X is the direction of X, and the distribution which integrates with a dot pattern 44 in the direction of Y which is the non-measuring direction, and is acquired turns into sharp distribution uniform in standup pars intermedia at the both ends of the direction of X, as the distribution curve 45 of drawing 6 (a) shows. That is, a dot pattern 44 is arranged along with the straight line of a large number parallel to the X-axis, and its location of the dot pattern on each straight line is mutually random.

[0043] On the other hand, as drawing 6 (b) shows the configuration of one alignment mark 35B on reticle 34 and it is shown in this drawing 6 (b), alignment mark 35B is the pattern which formed the light-shielding film in the shape of a straight line. In this case, the width of face of the direction of X of the profile of the image which projects ISS mark 37X on reverse through a projection optical system 3 at a reticle 34 side, and is obtained is set up to the same extent as the width of face of the direction of X of alignment mark 35B.

[0044] By return and this example, the illumination light IL 2 of the same wavelength as the exposure light IL 1 is led to the interior of the wafer stage 13 from the light source for exposure through the optical fiber 23 at drawing 5 . And the illumination light IL 2 injected from the optical fiber 23 illuminates ISS mark 37X from the base side of the reference mark plate 36 through a condenser lens 38. When ISS mark 37X is in the image field of a projection optical system 3, the diffracted light from ISS mark 37X passes through the circumference of the pupil filter 4 of a projection optical system

3, and carries out image formation of the image of ISS mark 37X to the pattern formation side of reticle 34. In this case, ISS mark 37X is the aggregate of a dot pattern, since the angle of diffraction of the diffracted light is large, many of diffracted lights from ISS mark 37X pass through the field of the exterior of the pupil filter 4, and image formation of the good image of ISS mark 37X is carried out on reticle 34.

[0045] The diffracted light from ISS mark 37X reaches a beam splitter 39 through a condenser lens 12 and a mirror 11, after penetrating reticle 34, and the light separated by the beam splitter 39 is condensed by the light-receiving side of an optoelectric transducer 41 with a condenser lens 40. The detecting signal S3 obtained by carrying out photo electric translation of the light which received light by the optoelectric transducer 41 is supplied to operation part 17A. The X coordinate and Y coordinate of the wafer stage 13 which were measured with the laser interferometer 15 are also supplied to operation part 17A, in operation part 17A, an X coordinate in case the image of ISS mark 37X and alignment mark 35B agree like the after-mentioned is detected, and the main control system 16 is supplied. Similarly, by operation part 17A, a Y coordinate in case the image of the ISS mark for Y-axes and the alignment mark for Y-axes agree is detected, and the main control system 16 is supplied. Other configurations are the same as that of drawing 1 .

[0046] In case reticle rotation is measured by this example, where ISS mark 37X is illuminated by the illumination light IL 2, the wafer stage 13 is driven in the direction of X, and alignment mark 35B is scanned in the direction of X by the image of ISS mark 37X. By this, in respect of the pattern formation of reticle 34, as shown in drawing 7 (a), image 37XP with bright ISS mark 37X will cross alignment mark 35B which consists of a light-shielding film in the direction of X. Therefore, since the detecting signal S3 outputted from the optoelectric transducer 41 of drawing 5 serves as min when image 37XP of an ISS mark agrees with alignment mark 35B, as shown in drawing 7 (b), it can detect the X coordinate at that time.

[0047] Similarly in drawing 5 , the location of the alignment mark for the X-axes left in the direction (direction vertical to the space of drawing 5) of Y to alignment mark 35B is detected using ISS mark 37X, and the angle of rotation of the reticle 34 to the Y-axis by the side of the wafer stage 13 is searched for from the difference of the X coordinate of two alignment marks. Similarly, the angle of rotation over the X-axis of reticle 34 is searched for by scanning an alignment mark long in the direction of X in the direction of Y by the long ISS mark for Y-axes in the direction of X.

[0048] Thus, as an ISS mark long in the direction of X for Y-axes, as shown in drawing 8 (a), the dot pattern which consists of minute opening is distributed in a rectangle field

long in the direction of X. Moreover, as a mark which doubled the ISS mark for the X-axes, and the ISS mark for Y-axes, as shown in drawing 8 (b), the ISS mark 37 which distributed the dot pattern which consists of minute opening in the field of a cross-joint mold may be used.

[0049] Next, with reference to drawing 9 and drawing 10 , it explains per 3rd example of this invention. This example applies this invention, when performing distortion measurement of a projection optical system, it gives the same sign to the part corresponding to drawing 1 in this drawing 9 , and omits that detail explanation. Drawing 9 shows the projection aligner of this example, and the test reticle 46 by which the mark Mij (i= 1, 2, --; j= 1, 2, --) for assessment was regularly formed on the reticle holder 9 is held in this drawing 9 . Although some enlarged drawings of the mark Mij for assessment are shown in drawing 10 (a), as shown in this drawing 10 (a), the mark Mij for assessment is arranged in a predetermined pitch in the direction of X, and the direction of Y, and each mark Mij for assessment distributes the dot pattern which consists of minute opening in the field of a cross-joint mold in a light-shielding film. The magnitude of each dot pattern is comparable as the magnitude of the contact hole pattern exposed through the projection optical system 3 with pupil filter 4 of drawing 9 . Moreover, distribution of the dot pattern in a rectangle field (mark section for the X-axes) long in the direction of Y of each mark Mij for assessment is the distribution to which the integral value to the direction of Y becomes homogeneity, and distribution of the dot pattern in a rectangle field (mark section for Y-axes) long in the direction of X is the distribution to which the integral value to the direction of X becomes homogeneity.

[0050] On the reference mark plate 36 on return and the wafer stage 13, the opening patterns 47X and 47Y (refer to drawing 10 (b)) are formed at drawing 9 . As shown to drawing 10 (b) in an enlarged drawing, a slit-like opening pattern with opening pattern 47X long in the direction of Y and opening pattern 47Y are the opening patterns of the shape of a slit long in the direction of X. And the width of face of the profile of the projection image to the wafer stage 13 top of the mark Mij for assessment on the test reticle 46 is set up almost equally to the width of face of the opening patterns 47X and 47Y.

[0051] In drawing 9 , in order, a condenser lens 48 and an optoelectric transducer 49 are arranged by the pars basilaris ossis occipitalis of the reference mark plate 36, and the light which passed the opening pattern on the reference mark plate 36 is condensed with a condenser lens 48 in the light-receiving side of an optoelectric transducer 49. The detecting signal outputted from an optoelectric transducer 49 is supplied to operation part 17B. The X coordinate and Y coordinate of the wafer stage 13 which were

measured by the laser interferometer 15 are also supplied to operation part 17B, and it is asked for the distortion of a projection optical system 3 by operation part 17B based on the supplied information. Other configurations are the same as that of drawing 1 .

[0052] In measuring the distortion in the condition of having been equipped with the pupil filter 4 of a projection optical system 3 by this example, where the test reticle 46 is installed on the reticle holder 9, it irradiates the exposure light IL 1 through a condenser lens 12 at the test reticle 9. Thereby, the image of the mark Mij for assessment on the test reticle 46 is projected into the image field of a projection optical system 3. While carrying out stepping actuation of the wafer stage 13 in this condition and scanning the image of each mark Mij for assessment in the direction of X by opening pattern 47X of the reference mark plate 36, the image of each mark Mij for assessment is scanned in the direction of Y by opening pattern 47Y. Under the present circumstances, since the detecting signal of an optoelectric transducer 49 becomes large in the location where opening pattern 47X agrees in the image and the direction of X of each mark Mij for assessment and the detecting signal of an optoelectric transducer 49 becomes large in the location where opening pattern 47Y agrees in the image and the direction of Y of each mark Mij for assessment, in operation part 17B, the X coordinate and Y coordinate of a projection image of each mark Mij for assessment are detected. By comparing this detection result with data in case there is no distortion, the distortion property of a projection optical system 3 is measured.

[0053] In this case, although the pupil filter 4 is arranged in this example at the pupil surface of a projection optical system 3, since each mark Mij for assessment on the test reticle 46 is the aggregate of a dot pattern, the angle of diffraction of the diffracted light by the exposure light IL 1 from each mark Mij for assessment is large [the mark]. Therefore, since many of diffracted lights from each mark Mij for assessment pass through the field around the pupil filter 4 by the pupil surface within a projection optical system 3 and image formation of the image of each mark Mij for assessment is carried out to the wafer stage 13 side at accuracy, the location of the image of each [these] mark Mij for assessment is detectable to high degree of accuracy. Consequently, there is an advantage which can measure the distortion property in the condition that the pupil filter 4 of a projection optical system 3 was installed, to high degree of accuracy.

[0054] Next, with reference to drawing 11 , it explains per 4th example of this invention. In this example, the projection aligner of drawing 9 is used and the distortion property of the projection optical system 3 in the condition of having been equipped with the pupil filter 4 according to double exposure is measured. For this reason, first, instead of each mark Mij for assessment on the test reticle 46 of drawing 9 , as shown in drawing

11 (a), the mark for assessment of the Y-axis obtained by rotating 90 degree of the mark 50 for assessment and this mark 50 for assessment of the X-axis which consists of the aggregate of a dot pattern 51 which consists of minute opening is used.

[0055] The mark 50 for assessment of the X-axis arranges partial pattern 50A in a predetermined pitch in the direction of Y, and each partial pattern 50A arranges a dot pattern 51 regularly in a square field mostly, respectively. In other words, the mark 50 for assessment is equivalent to what distributed the respectively minute dot pattern 51 in the pattern of each square of the conventional mark RM 3 for assessment shown in drawing 18 , and the magnitude of a dot pattern 51 is magnitude comparable as the subject-copy pattern of the contact hole pattern which can be exposed by the projection optical system 3 with pupil filter 4.

[0056] In this example, the mark for assessment which consists of a mark 50 for assessment of the X-axis and a mark for assessment of a Y-axis exposes first all the patterns of the test reticle arranged regularly on a wafer 5 through the projection optical system 3 with pupil filter 4 in the projection aligner of drawing 9 . Then, the image of the predetermined mark for assessment of them is exposed on a wafer 5, carrying out stepping actuation of the wafer stage 13, and the amount of location gaps of two marks (resist pattern) formed of double exposure after development is measured. In this case, it is the off-axis method which does not mind a projection optical system, for example, and these two marks are scanned with slit-like spot light using the alignment system of a LSA (laser step alignment) method, the diffracted light generated in the predetermined direction is detected, and the location of two marks is detected. The art of the obtained measurement data is the same as usual.

[0057] Since the angle of diffraction of this example of the diffracted light which the mark 50 for assessment on test reticle is the aggregate of a minute dot pattern, and generates is large, even if it uses the projection optical system 3 equipped with the pupil filter 4, on a wafer, the exact image of the mark 50 for assessment is exposed. Therefore, the distortion property of the projection optical system 3 can be evaluated to accuracy. And the conventional metering device also has the advantage which can be used as it is as a metering device of an off-axis method.

[0058] In addition, the mark 52 for assessment of the X-axis which consists of small line - and - tooth-space pattern of an array pitch as shown in drawing 11 (b) instead of the mark 50 for assessment of the X-axis of drawing 11 (a) may be used. The mark 52 for assessment of this X-axis arranges partial pattern 52A in a predetermined pitch in the direction of Y, and each partial pattern 52A arranges line - and - tooth-space pattern 53 in a pitch detailed in the direction of Y in a square field mostly, respectively. In other

words, the mark 52 for assessment is equivalent to what distributed line [of a respectively detailed pitch] -, and - tooth-space pattern 53 in the pattern of each square of the conventional mark RM 3 for assessment shown in drawing 18 , and the pitch of line - and - tooth-space pattern 53 is magnitude comparable as the array pitch of the subject-copy pattern of the contact hole pattern which can be exposed by the projection optical system 3 with pupil filter 4. Even when a mark 52 for assessment like drawing 11 (b) is used, the angle of diffraction of the diffracted light to generate is large, and many of diffracted lights to generate pass through the field of the outside of the pupil filter 4 within a projection optical system 3. Therefore, the image of the mark 52 for assessment is exposed by accuracy on a wafer, and distortion measurement of a projection optical system is carried out to high degree of accuracy.
[0059] In addition, although this example changes whenever [of the mark for distortion measurement of a projection optical system / detailed] with the conventional example, it may form the alignment mark for degree processes in the pattern space of the reticle for the usual contact hole pattern exposure, for example as the aggregate of a minute dot pattern. In this case, since that alignment mark is also exposed by accuracy on a wafer in parallel to exposure of a contact hole pattern, in case the following circuit pattern is exposed in that upper layer, superposition precision can be raised by using that alignment mark.
[0060] Moreover, although the mark Mij for a reference mark 22, ISS mark 37X, and assessment, the mark 50 for assessment, and the mark 52 grade for assessment are used in each above-mentioned example, it cannot be overemphasized that the mark which reversed the light and darkness (or transparency/nontransparent) of these marks may be used. Moreover, by raising whenever [detailed] with the application of this invention also to such a diffraction-grating-like mark, although the diffraction-grating-like mark made applicable to detection as a reference mark by the so-called 2 flux-of-light interference method for injecting the diffracted light of the 2 coherent flux of lights in the same direction mutually is also used, even when the pupil filter is installed, detection becomes easy.
[0061] Furthermore, base-line measurement which searches for the difference (base line) of the detection core of the alignment system of various TTL (through THE lens) methods and a actual exposure location is also performed by using the reference mark formed on [other than the application of each above-mentioned example] the reference mark plate on the wafer stage 13 (for example, 21). By using the mark which raised whenever [detailed] like the above-mentioned example also as a mark in this case, even if the pupil filter is arranged near the pupil surface of a projection optical system,

base-line measurement is carried out to high degree of accuracy.

[0062] next, as a pupil filter for improving the image formation property of a detailed isolated pattern like a contact hole pattern It sets near the pupil surface of a projection optical system as proposed not only by the pupil filter of the above protection-from-light molds but by Japanese Patent Application No. No. 263521 [four to] and Japanese Patent Application No. No. 271723 [four to]. For example, the pupil filter of the so-called SFINCS method which reduced the coherency between the transmitted light of a core, and the transmitted light of a periphery, and collection of drafts 29 a-ZC- of the 1991 spring Japan Society of Applied Physics -- the so-called Super which it was announced [Super], for example, reverses the phase of the transmitted light of the core of the pupil surface of a projection optical system, and the transmitted light of a periphery by 8 and 9 There is a pupil filter of a FLEXS method etc. Also when such a pupil filter is installed near the pupil surface of a projection optical system, in case it observes a mark through a projection optical system or the mark for measurement is projected through a projection optical system, there is a possibility that good image formation may be barred with the pupil filter.

[0063] then, also in such a case, whenever [of the mark for / for observation / projection / detailed] is changed, the permeability in the pupil filter near the pupil surface of the projection optical system has a large light from the mark, and when phase distribution also enables it to pass through the field of about 1 law, observation or projection of the mark is performed good. What is necessary is just to determine whenever [the / detailed] that the light from a mark will pass along the inside of the field where an optical operation (special feature) is the same among pupil filters, if it puts in another way. Furthermore, when exposing periodic patterns which crowded comparatively, such as line - and - tooth-space pattern, in collection of drafts 12 a-ZF -7 of the 1991 autumn Japan Society of Applied Physics, and the collection of drafts 30 p-NA-5 grade of the 1992 spring Japan Society of Applied Physics, the pupil filter which changed the circular field centering on an optical axis and the field of the shape of zona orbicularis of the circumference of it in permeability is also proposed as a pupil filter which raises resolution and the depth of focus. In using such a pupil filter, in case it observes a mark through a projection optical system or exposes the mark for measurement through a projection optical system, there is a possibility that good image formation may be barred with the pupil filter.

[0064] Then, when whenever [of the mark for / for observation / projection / detailed] is raised also in such a case and the light from the mark enables it to pass through the field where the permeability in the pupil filter near the pupil surface of the projection

optical system is large, observation or projection of the mark is performed good. Usually, as for the pupil filter for periodic patterns, the permeability of a central circular field has become smaller than the permeability of a surrounding zona-orbicularis field. Therefore, what is necessary is just to determine whenever [of a mark / detailed] that the light from a mark will pass along a surrounding zona-orbicularis field in this case. Moreover, when determining whenever [of a mark / detailed] that the light from a mark will pass especially through the inside of a periphery (field where the optical special feature of a pupil filter is the same) among the effectual pupil surfaces of a projection optical system 3, for example in drawing 1 , it is necessary to take into consideration the effective diameter of a pupil surface, i.e., the numerical aperture of a projection optical system 3. That is, when whenever [of a mark / detailed] is made small (pitch etc.), it is for a part of light from a mark not carrying out incidence to a projection optical system 3. Thus, this invention is not limited to the above-mentioned example, but can take configurations various in the range which does not deviate from the summary of this invention.

[0065]

[Effect of the Invention] According to the 1st projection aligner of this invention, whenever [of the reference mark / detailed] is adjusted so that many of light (diffracted light etc.) generated from the reference mark on a substrate stage can pass through near [the] a pupil surface according to the configuration of the pupil filter near the pupil surface of a projection optical system. Therefore, through the projection optical system in which the pupil filter was prepared, the light from the reference mark can fully be received, and there is an advantage which can detect the reference mark good (observation).

[0066] Moreover, according to the 2nd projection aligner, whenever [of the reference mark / detailed] is adjusted so that many of light (diffracted light etc.) generated from the reference mark on a mask can pass through near [the] a pupil surface according to the configuration of the pupil filter near the pupil surface of a projection optical system. Therefore, through the projection optical system in which the pupil filter was prepared, the light from the reference mark can fully be received, and there is an advantage which can detect the reference mark good (observation).

[0067] When distribution of the integral value to the non-measuring direction of the bright section of these reference marks is equalized in these cases, by repeating and measuring the reference mark in the non-measuring direction, and equalizing a measurement result, the repeatability of the measurement result of the location of the reference mark increases, and the measurement precision of a location improves.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is the block diagram showing the 1st example of the projection aligner by this invention.

[Drawing 2] The amplification top view in which (a) shows the reference mark 22 in drawing 1 , and (b) are the amplification top views showing alignment mark 8B in drawing 1 .

[Drawing 3] It is the amplification top view showing the image observed under the alignment microscope of drawing 1 .

[Drawing 4] When a reference mark 22 is changed into another reference mark in the 1st example, it is the amplification top view showing the image observed under an alignment microscope.

[Drawing 5] It is the block diagram which cut and lacked the part which shows the projection aligner of the 2nd example of this invention.

[Drawing 6] The amplification top view in which (a) shows ISS mark 37X of drawing 5 , and (b) are the amplification top views showing alignment mark 35B of drawing 5 .

[Drawing 7] It is an explanatory view in case a stage luminescence method performs location detection of alignment mark 35B in the projection aligner of drawing 5 .

[Drawing 8] The amplification top view in which (a) shows ISS mark 37Y for Y-axes, and (b) are the amplification top views showing the ISS mark 37 of a cross-joint mold.

[Drawing 9] It is the block diagram which cut and lacked the part which shows the

projection aligner of the 3rd example of this invention.
[Drawing 10] The amplification top view in which (a) shows a part of mark for assessment of drawing 9 , and (b) are the amplification top views showing the opening pattern formed on the reference mark plate 36 of drawing 9 .
[Drawing 11] The amplification top view showing the mark 50 for assessment for which (a) is used in the 4th example of this invention, and (b) are the amplification top views showing the modification of the mark for assessment used in the 4th example.
[Drawing 12] It is the amplification top view showing the reference mark and alignment mark which are used by the conventional reticle alignment.
[Drawing 13] It is the principle explanatory view of the location detection at the time of using the mark of drawing 12 .
[Drawing 14] It is the amplification top view showing the alignment mark to which the stage luminescence mold used by the conventional reticle rotation measurement corresponds [on which correspond and it ISS-marks].
[Drawing 15] It is the principle explanatory view of the location detection at the time of using the mark of drawing 14 .
[Drawing 16] It is the amplification top view showing other examples of the conventional ISS mark.
[Drawing 17] The explanatory view showing the image formation condition by the projection optical system in which (a) inserted the conventional pupil filter, and (b) are the enlarged drawings showing the intensity distribution of the projection image by the projection optical system.
[Drawing 18] It is the amplification top view showing the mark used by distortion measurement of the conventional double exposure method.
[Description of Notations]
1 34 Reticle
3 Projection Optical System
4 Pupil Filter
5 Wafer
8A, 8B Alignment mark
9 Reticle Holder
13 Wafer Stage
15 Laser Interferometer
16 Main Control System
17 Operation Part
22 Reference Mark

23 Optical Fiber
29X, 29Y Image sensor
37X, 37Y, 37 ISS mark
41 Photo Detector
42 Dot Pattern
Mij Mark for assessment
46 Test Reticle
47X, 47Y Opening pattern